ICEUBI2015 University of Beira Interior Faculty of Engineering Covilhã | Portugal
December 2 3 4 International Conference on Engineering
Engineering for Society

Physical properties of Physalis Peruviana L.

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Abstract
Physalis (Physalis Peruviana L), also known as Cape Gooseberry or Ground-cherry, plays an important role in nutrition being an excellent base for dietetic products. Highly valued for its unique flavor, texture and color, recent research has shown that physalis is rich in many beneficial compounds. In this study were evaluated some biometric characteristics of physalis, such as the diameter and mass, and which allowed calculating others, like: surface area, volume or density. Other physical properties were also evaluated, namely the color coordinates, by means of a Chroma metter, and textural parameters evaluated by a texturometer: firmness and elasticity. The physalis analyzed in the present work have an average diameter of 1.69 cm, a surface area of 8.98 cm2, a volume of 2.51 cm3, a mass of 2.77 g and a density of 1.10 g/cm3. The color coordinates were found to be 56.72 for lightness, 16.69 for redness and 58.11 for yellowness. Regarding texture, two attributes were evaluated, namely skin firmness and elasticity, and the average values found were 2.40 N and 2.94 mm, respectively. The results of this work are in accordance with data from literature reported by other authors.

Keywords
Physalis peruviana L., Diameter, Mass, Color, Texture.

Physical properties of *Physalis Peruviana* L.

Conference Topic – TS1 – Food Engineering and Properties

1. Introduction

Exotic fruits play an important role in nutrition being an excellent base for dietetic products with beneficial bioactive compounds and low energetic value. Highly valued for its unique flavor, texture and color, recent research has shown *Physalis Peruviana L.* to be very rich in many beneficial compounds [1].
The *Physalis* genus, which includes approximately 100 species, is originating from the Andes, with tropical global distribution, now expanding to moderate climates, such as in Portugal. The majority of the species is wild, but some species are cultivated in countries such as Colombia, Mexico, China, Japan and more recently in Brazil and also in Portugal. These countries have as main consumer market the European countries, mainly of fresh fruits, because its fruits are used as food and also in pharmaceutical industry. Only recently has the plant become an important crop; it has been widely introduced into cultivation in other tropical, subtropical and even temperate areas. *Physalis peruviana* have numerous common names according to the country and/or regions [2,3]. These include: cape gooseberry (South Africa, UK), Inca berry, Aztec berry, golden berry, giant ground cherry, African ground cherry, Peruvian groundcherry, Peruvian cherry, “amour en cage” (France), and sometimes simply Physalis (United Kingdom).
Physalis has a short cycle. It can be planted any time of year, adapting in any warm climate and expressing tolerance to cold. However, it does not like excess moisture or frost. The flowers are bell-shaped, but the most distinctive feature is the fruiting calyx which enlarges to cover the fruit and hangs downwards like a lantern. Physalis forms a domed shrub that can grow up to 1 m. The flowers, produced in winter, are yellow with purple blotches. Physalis is an herbaceous, semi-shrub, that is upright, perennial in subtropical zones. The fruit with an approximate weight of 4–5 g is protected by an accrescent calyx and covered by a brilliant yellow peel [1].
The fruit is a juicy berry with ovoid shape and a diameter between 1.25 to 2.50 cm, 4 and 10 g weight, containing inside around 100 to 200 small seeds, the fruit is protected by the calyx or fruit basket which completely covers the fruit along its development and ripening, protecting it against insects, birds, diseases and adverse climatic situations [4].
The lifetime of the plant production goes from nine to eleven months from the time of the first harvest, since thereafter both the productivity and fruit quality decrease. The shelf life of the fruit with the calyx is one month but without it is just 4 to 5 days [1].

2. Experimental Procedure

2.1. Sampling

For this work was evaluated one variety of Physalis (*Physalis peruviana* L.), and the fruits were harvested from one farm located in the North-Centre region of Portugal. The Physalis were original from conventional production mode.
The fruits were harvested in maturity state. Approximately 750 g of berries were collected, being selected randomly from several plants in different parts of the same field.

Figure 1 – *Physalis peruviana* bush and fruit.

2.2. Handling and conservation

After harvesting, the samples were transported to the laboratory in appropriate plastic cuvettes protected from light and refrigerated.
The properties were then evaluated in the fresh samples under refrigeration at a temperature of 4 ºC and 85 to 90% relative humidity (RH).

2.3. Biometric characteristics

For the evaluation of biometric characteristics, weight and size, around 100 berries were randomly selected as representative of the sample. The size of each berry was measured with the aid of an automated caliper rule and the weight was determined through a precision scale.
Volume and surface area was calculated assuming a sphere shape and specific mass was calculated dividing the mass by the volume.

2.4. Color measurement

The color of Physalis was determined with a colorimeter (Chroma Meter - CR-400, Konica Minolta) in the CIE Lab color space, assessing the Cartesian coordinates L*, a* and b*. The illuminant was D65. The L* axis represents Lightness and varies from 0 (corresponding to no lightness, i.e., absolute black), to 100 which is maximum lightness (i.e. absolute white). The other axes are represented by a* and b* and they are at right angles to each other. The a* axis varies from green at one extremity (represented by -a) to red at the other (+a), whereas the b* axis varies from blue at one end (-b), to yellow (+b) at the other. Although in theory there are no extreme values of a* and b*, in practice they can be numbered from -128 to +127.
The chroma is the ratio between the values of a* and b*, according to the formula that is given in the paper (2). Hue angle is the angle between the a* and b* axes, indicating the color saturation of the subject [5].
The coordinates for value, colour intensity (Chroma) and hue angle were calculated using the following Equations [6]:

$$\text{Value} = \frac{L^*}{10} \quad (1)$$

$$\text{Chroma} = \sqrt{a^{*2} + b^{*2}} \quad (2)$$

$$Hue\ angle = \tan^{-1}\left(\frac{b^*}{a^*}\right) \quad (3)$$

For the colour evaluation, also 100 berries were examined.

2.5. Texture analysis

To determine the texture attributes (skin strength and elasticity) 100 berries were randomly selected as representative of the sample. The analyzes were performed with a texturometer TA.XT Plus, from Stable Micro Systems, using a 2 mm probe (P/2), with the following test conditions: pre-test speed = 1.50 mm/s, test-speed = 1.00 mm/s, post-test speed = 10.00 mm/s, distance = 6 mm, trigger force = 0.05 mm and a load cell of 50 kg. The results were treated with Exponent software TEE (Stable Micro Systems) and from the obtained texture profile (Figure 2) was determined firmness (strength on the highest peak) and elasticity (distance at the highest point). The number of samples used for texture evaluation was 100.

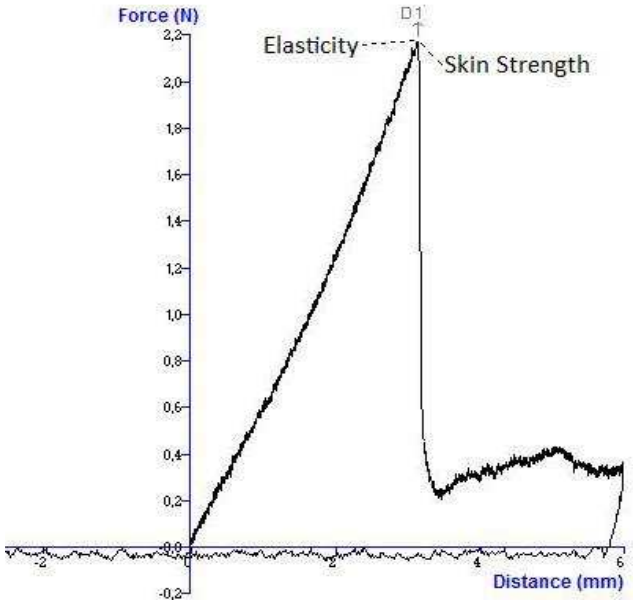

Figure 2 – Texture profile analysis for Physalis.

3. Results and Discussion

3.1. Biometric characteristics

In Table 1 are presented the mean values and the corresponding standard deviation for the diameter, volume, mass and specific mass.
It can be seen that the value obtained for the diameter is 1.67 ± 0.14 cm. According to the authors Lechese et al. [2] and Puente et al. [4], the diameter of the berries can vary between 1.25 and 2.50 cm. Hence, the value obtained is within the standard values.

Table 1 – Biometric characteristics of physalis.

Diameter (cm)	Surface area (cm^2)	Volume (cm^3)	Mass (g)	Specific mass (g/cm^3)
1.69 ± 0.16	8.98 ± 1.28	2.51 ± 0.59	2.77 ± 0.67	1.10 ± 0.04

The value obtained for the mass of the berries is 2.77 ± 0.67 g. According to the authors Lechese et al. [2] and Puente et al. [4], the mass may vary between 4 to 10 g, and the values found in the present work are lower than those, although lying close to the lowest limit of the interval. Variations may be due to the state of maturity in which the berries were collected or the climate conditions and soil of the region where the berries were produced.
The value obtained for the surface area is 8.98 ± 1.28 cm^2. The average volume of the berries is 2.51 ± 0.59 cm^3 and the specific mass is 1.10 ± 0.04 g/cm^3. Comparing with the results obtained by Puente et al. [4], the value is quite similar, although just slightly higher, since their results pointed a value of 1.038 ± 0.0054 g/cm^3.

3.2. Color

Table 2 shows the values for chromatic coordinates: the Cartesian coordinates (L*, a* and b*) as well as the cylindrical coordinates (V, H° and C).
The coordinate L* corresponds to a value of 65.72 ± 3.13, and allows to conclude that the berries are clear, because the value is closer to 100 (white) than to 0 (black). Comparing with the results obtained by Puente et al. [4], it is found that the berries in the present work are slightly clearer than those analyzed by the authors, for which L* ranged between 70.31 ± 0.39 and 71.37 ± 1.10.

Table 2 – Chromatic coordinates in physalis

Cartesian coordinates			Cylindrical coordinates		
Lightness L*	Redness a*	Yellowness b*	Value V	Chroma C*	Hue Angle H°
65.72 ± 3.13	16.69 ± 2.70	58.11 ± 3.21	6.57 ± 0.31	60.64 ± 3.19	73.95 ± 2.57

The coordinate a* was found to be 16.69 ± 2.70. This coordinate correspond to red color when positive, as in the present case, and the redness is more intense as the value increases. Puente et al. [4], found values obtained for this coordinate ranging between 14.31 ± 1.28 and 15.20 ± 0.48. Hence, the berries evaluated in this work have a slightly more intense red coloration. The value of the coordinate b* is 57.94 ± 3.60, and because it is positive lies within the color spectrum of yellow. Comparing with the results of the authors Puente et al. [4], who reported values for this coordinate varying from 60.84 ± 3.10 and 61.76 ± 1.34, it is observed that the berries in the present work are marginally less yellow. The slight differences found in the color coordinates may naturally occur due to different maturity stages, cultivar or cultivation procedures.
It is found that the value the chroma is 60.64 ± 3.19, being slightly inferior to those described by Puente et al. [4], in the range from 63.61 ± 1.40 to 62.50 ± 3.26. For the hue angle was obtained a value of 73.95 ± 2.57, which is once again slightly lower than the values found by Puente et al. [4], since the range of values they reported for this color coordinate was from 76.77 ± 0.57 to 76.20 ± 0.26.

3.3. Texture

Table 3 presents the values for the textural attributes evaluated: firmness and elasticity. The firmness reflects the integrity of the pericarp tissue, wherein the value obtained is 2.40 ± 0.53 N. According to the authors Trinchero et al. [7], the firmness of the physalis berries in their study was 3.42 ± 0.32 N, and therefore the value obtained in the present study is lower than that referenced by the author. As to elasticity the value obtained is 2.94 ± 0.54 mm. Differences observed may come from the state of maturity, among other factors.

Table 3 – Texture characteristics of physalis

Firmness (N)	Elasticity (mm)
2.40 ± 0.53	2.94 ± 0.54

4. Conclusions

The results of the present work showed that the physalis berries analyzed have an average diameter of 1.69 cm, a surface area of 8.98 cm^2, a volume of 2.51 cm^3, a mass of 2.77 g and a density of 1.10 g/cm^3. These biometric characteristics are relatively similar to those reported in literature for the same product.
The color coordinates were found to be 56.72 for lightness, 16.69 for redness and 58.11 for yellowness, which do not differ much from values found in literature also for physalis berries.
Regarding texture, two attributes were evaluated, namely skin firmness and elasticity, and the average values found were 2.40 N and 2.94 mm, respectively. Comparing with data from literature for firmness, the values are in accordance with those reported by other authors.

Acknowledgement

The authors thank Research Centre CI&DETS and Polytechnic Institute of Viseu for financial support.

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